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Evaluation Of Performance Degradation Due To The Presence Of Bottleneck Intermediate Node In Communication Path In Manet

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Abstract: ***In order to have effective communication in any network, routing protocol must select the efficient path and forward the information through selected path in the form of packets. In MANET most of the routing protocols select the routing path by assuming that the node present in the network are supportive for networking functionalities. However, nodes present in the MANET are having constrained resources such as battery, computational capacity and memory. These limiting factors causes the networking functionalities to be vulnerable, and drop the packets form routing path. One such situation in the network layer is the formation of bottleneck intermediate node. In this paper we evaluate the performance of network during the formation of bottleneck intermediate node in the communication path. Performance results indicate that the bottleneck intermediate node is a serious problem, and conclude that the appropriate mechanisms are needed to overcome the problem of bottleneck intermediate node formation in the communication path.***

Index Terms**:** ***MANET, Bottleneck node, Communication, Routing.***

I. INTRODUCTION

Wireless communication is possible either with the help of infrastructure or without the use of infrastructure. Communication is happening in infrastructure based network is through central coordinator, or base station or router or access point. Whereas infrastructure less network achieves the communication without the help of central coordinator. Thus this network is called peer to peer network. If communicating nodes present in the radio communication range of each other then they communicate directly or else they need to be relay on other nodes to have communication. For this purpose nodes in the network must be act as a rooter as well as host. In order to act as a router, the node must contribute its resources for receiving, transmitting and processing the packets, in the form of energy, memory and computation. Example of wireless infrastructure less network is the Mobile ad hoc network, MANET in short. The characteristics of MANET includes adaptation, self-forming, autonomous and peer to peer network [2].

In order to have efficient communication between communicating entities, routing protocol must establish efficient path between the source and destination. However, deciding the efficient path between source and destination in resource constrained environment is a difficult task i.e., such as in infrastructure less network. Memory and energy of nodes are two major contained resources which limits the routing functionalities of MANET. Number of energy efficient and buffer aware routing protocols designed for MANET to improve the energy efficiency and packet delivery. Majority of these routing protocols are congestion non control type. Congestion is the phenomena in network, when the node buffer or link receive the packets more than its handling capacity, and then node becomes bottleneck.

For instance, an intermediate node (router) becomes a bottle-neck. If the packets arrive at the input interface of buffer greater than its processing capacity, then queue at the input buffer will grow. If the queue grows greater than the buffer capacity, then the packets will drop from the node. This situation is majorly reflected by the route finding metric of the routing protocol. When the node at the current energy satisfies a certain kind of threshold level as a metric to find the route for communicating entities, then the node's characteristics may be the reason to become a node to bottle-neck intermediate node and cannot assure the reliable communication for a massive traffic scenario. This situation in a network directly impacts on performance degradation of the network due to packet loss, decreases the network lifetime and drains the energy of a node.

In this paper we evaluate the performance degradation due to the presence of bottleneck intermediate node in the communication path for reactive routing protocols, such as AODV and DSR. The reminder of paper is organized as follows: section 2 describes the related work regarding performance evaluation of network during the presence of bottleneck intermediate node. Section 3 describes the performance evaluation and our paper ends with the conclusion followed by references.

II. RELATED WORK

MANET is an infrastructure-less network with heterogeneous mobile nodes. In this network environment, congestion may occur at any intermediate node buffer during data communication from source to destination. This congestion causes the highest number of packet loss, increases the network delay and causes a negative impact on network performance. Congestion control happens in the infrastructure based network through the transport layer protocols and is independent of the other layer protocols.

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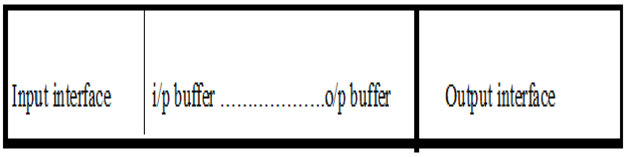
However, these techniques cannot apply directly to infrastructure-less networks such as MANET. Thus, congestion is a dominant issue for the loss of packets in the MANET and leads an intermediate node to turn into a bottleneck intermediate node, which is explained in the next section



MANETs is a multi hop peer to peer network. If both source and destinations are not present in a radio communication range of one another then they communicate with the help of an intermediate nodes. In order to support communication, nodes present in a network must act as a router. Thus node must have sufficient energy, buffer and processor to act as a router. The node's buffer internal structure is shown in figure. Whenever node receive the packets from different sources, initially it to hold the packets in its buffer for small interval of time, and then forward the packet further according to protocol specifications. The internal mechanism of node buffer regarding packet operation is explained as follows:

The packets coming to the buffer's input interface are placed at a queue of input buffer until they attain an edge of the queue and waits until they undergoes the decision module.

Decision modules take the packets from a buffer's input interface and take the decision about the packets regarding the processing with the help of current running network protocol.

Then the packets are put at buffer's output interface, where packets wait until their turn to transmit form node.

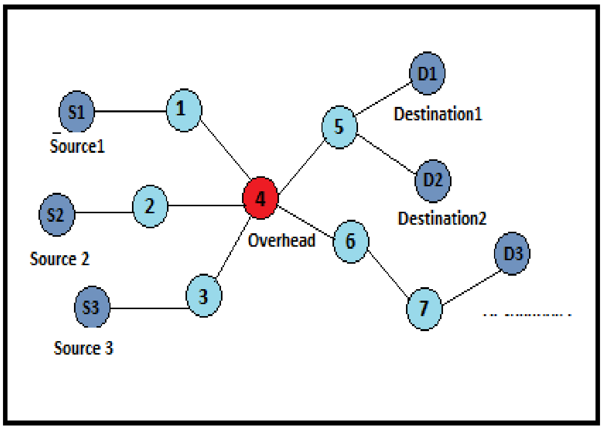


Figure 2-: Formation of bottleneck intermediate node

An intermediate nodes or routers become a bottle-neck. If the packets arrival rate at the buffer's input interface more than its dispensation ability, then it creates the queue of packets at buffer's input interface. This type of condition is occur due to the inefficient route finding metrics of the routing protocols. If the queue grows greater than the buffer capacity, then the packets will drop from the node. This situation is majorly reflected by the route finding metric of the routing protocol. When the node at the current energy satisfies a certain kind of threshold level as a metric to find the route for communicating entities, then the node may be the reason to become a bottle-neck [4] and cannot assure the reliable communication for a massive traffic scenario. This situation in a network directly impacts on performance degradation of the network due to packet loss, decreases the lifetime of network and fixtures the energy of a node. Figure 2 shows the bottle-neck intermediate node at node

Existing work [1] regarding the presence of bottleneck node evaluation is mathematically evaluate the probability of packets drop due to the presence of bottleneck intermediate node in communication path. Considered packet dropping reasons are buffer overflow, packet waiting time inside the buffer than its lifetime. The work evaluated the performance by poison random process approximation as follows [3]:

An intermediate node must be active node and must not be sleeping node, i.e., ready to process the packets from different sources

Node must has require amount of resources to process the packets

The buffer capacity of node is let "B" and it can store "N" number of packets

Packets coming from different sources to Intermediate node are queued in buffer and transmitted according to MAC protocol specification

An Intermediate node can process the maximum "n" number of packets in a given time interval "T", $(n > 1)$.

Congestion occur at intermediate node buffer if the number of packets comes to intermediate node more than "n" number in a given time interval "T", where $(n = 1,2,3 \ldots.)$

In order to compute the packet drops due to buffer overflow from an intermediate nodes is explained as follows

Let the buffer utilization of an intermediate node is happen at random by arriving packets, then the packets coming to node buffer from multiple sources in given time intervals are $(n = 1,2,3 \ldots.)$. Let 'ϑ' be the mean value represents the buffer utilization of an intermediate node by the arriving packets in a small interval of time 'Δt'.

$$\vartheta = \frac{\text{buffer utilization}}{\textit{Number of packets}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Equation (1) is valid by following assumptions

Probability of buffer utilization of intermediate node due to single packet arrival in a time interval 'Δt is denoted by Δt , in $(t,\ \Delta t)$. And this buffer utilization is independent in any another interval of time.

At the same time no buffer utilization of termediate node in a time interval 'Δt is denoted $1 - \vartheta\Delta t$.

We use the poison random process to compute the exact δ amount of buffer utilization of intermediate node in a time interval let 't' with 'n' arrival of packets, is given s follows

$$P(\delta) = \frac{(\vartheta t)^{\delta}\ e^{-\vartheta t}}{\delta!} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

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The probability of $'n'$ number of packets present in the node buffer is computed by following equation, (3) .

$$\left(\alpha/_{\beta}\right)^{n}\left(1+\left(\frac{\alpha}{\beta}\right)\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where,

$\alpha = packets\ arrival\ rate$

and

$\beta = packets\ departure\ rate$

If the packet wait inside the node buffer more than its lifetime also get drop from node buffer than let time interval $'TTL'$ [7,8], and it is computed as by equation, (4)

$$\frac{\alpha}{\beta}\left(e^{-(\alpha-\beta)*t}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

This work only consider the packet loss due to the presence of the traffic by the following consideration, such as An Intermediate node of routing path needs to forward the packets from multiple sources. Packets are arrived from a large number of independent sources towards the intermediate node, thus the Traffic is Poisson Distribution Model [6]

Number of sources is unknown

Traffic arrival pattern is random

III. PERFORMANCE ANALYSIS

In order to evaluate the node buffer status, we consider the multi hop wireless ad hoc network consist of 100 mobile nodes distributed in wireless communication area of 1000x1000 sq units. Every node has the buffer capacity to hold 10 packets and time to live of each packet is 200ms. We consider the variable packet arrival and departure times. We evaluate the performance of existing reactive and proactive routing protocols under the presence of bottleneck intermediate node situation. Performance results of reactive and proactive protocols are shown in figure 3 and 4. Results are very much clear that the performance of network drastically reduced in the presence of the bottleneck intermediate node and large number of packets get dropped from the network.

Packet delivery fraction of the network is shown in figure 3, under the bottleneck intermediate node environment. The basis for our simulation scenario is considered form the work [5], where multiple nodes are trying to forward the packets through an intermediate node. Packet loss of the network is shown in figure 4, under the bottleneck intermediate node environment.

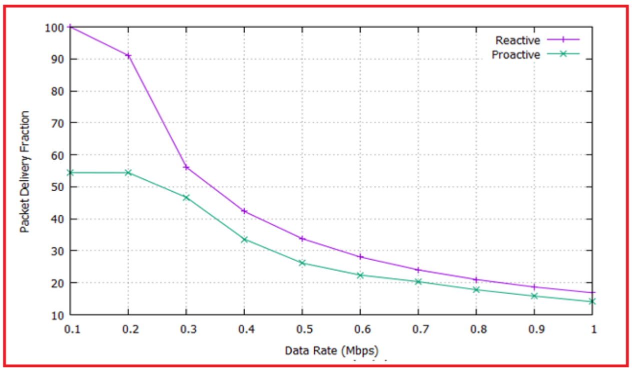

Figure 3-: Packet delivery fraction in MANET during heavy traffic towards the specific node during communication

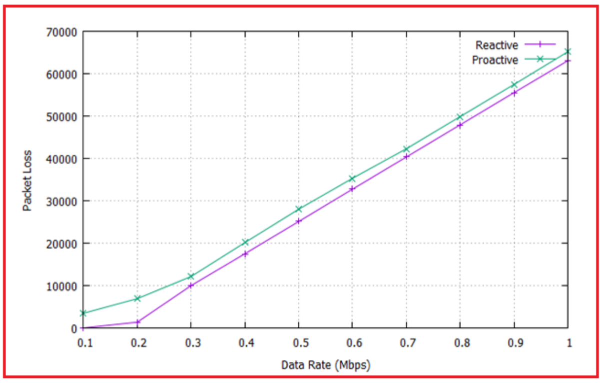

Figure 4 -: Percentage of packet loss in MANET during heavy traffic towards the specific node during communication

V. DISCUSSION

From the results we conclude that the node buffer for the communication process is an important factor. If it do not handled properly then the node becomes bottleneck. The huge traffic towards the node buffer is caused by either medium access or packet forwarding. Thus there is a need of an efficient routing protocol, which can detect the packet queue at the node buffer, so that we can remove the packet loss and improve the packet delivery. That interns mitigate the formation of bottleneck intermediate node in the communication path.

VI. CONCLUSION

This paper evaluates the performance degradation due the formation of a bottleneck intermediate node in the communication path. Existing routing protocol do not prevent the bottleneck intermediate node. Bottleneck intermediate node is caused by buffer overflow, which is due to high traffic towards the node buffer during communication. Results indicates that the performance of the communication network drastically degrade due the formation of the bottleneck intermediate node. Thus we conclude that the MANET require a routing mechanism, which must mitigate the bottleneck intermediate node form communication path.

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